POWER SUPPLIES
High Density Module (HDM)

Applying Commercial-Off-The-Shelf (COTS) Technology to Multiple Weapon Systems

Final Technical Report
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Executive Summary

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The Power Supplies High Density Module (HDM) Standardization Study addresses the application of state-of-the-art electronics technology within various U.S. Army Aviation and Missile (AMCOM) programs. HDM power micro-systems are simple, cost-effective assemblies that provide the necessary functions for distributed power. Much data for the study is drawn from the commercial market where the use of HDMs in power supplies is a technology that has matured to a point where it has become a very cost-effective concept. This study utilizes this private-sector information as the baseline to assess the progress being made within the U.S. Army to adapt and integrate HDM application theory to missile and aviation hardware.

The HDM concept is structured on a building block approach that is used to develop the power and voltage needs of the supported system. The approach adds redundancy and significantly increases mean-time-between-failures (MTBF). Historically, this approach, when coupled with the increased efficiency (i.e. reduction of power loss), has produced significant overall power consumption economies for the systems where it has been applied. This study also found that the maintenance concept for power sources has evolved toward a simpler, more expedient process. The modules are plug-in units each containing a built-in failure indicator that requires a lesser skilled maintainer to remove and replace the module at the field level. This approach reduces the mean-time-to-repair (MTTR) while increasing the system reliability, availability and maintainability (RAM). Consequently, enhanced RAM reduces spares levels throughout the logistics pipeline. Previously, the complete power supply had to be stocked as a spare at the forward units. When a failure occurred, the complete power supply was replaced and the broken unit was evacuated to a depot/contractor for repair. The new HDM approach reduces the required stockage to standard modules and eliminates the rebuild/repair program for the complete units. Changes in the standardization and maintenance concept should result in significant investment cost reductions in Authorized Stockage List (ASL) and Prescribed Load List (PLL) authorized levels.

This study effort found that the initial application of the HDM technology at AMCOM was in the PATRIOT missile hardware. While ongoing, the concept has been applied to five of the programs twenty power supplies. All tests through the individual applications have proven successful, however, the system validation phase remains to be completed. This study also addresses the extension of the HDM technology to the remainder of the PATRIOT, National Missile Defense (NMD) Radar, ARROW, Theater High Altitude Area Defense (THAAD), Medium Extended Air Defense Systems (MEADS), and Joint Tactical Ground Station (JTAGS) programs. While programs such as NMD Radar and MEADS are in early development stages, the timing is right to consider HDM standardized applications early in their respective life cycles.

This study effort recommends expansion of the HDM application throughout both the PATRIOT and THAAD programs. The other system managers will be provided the data and every effort will be made to influence the design engineers to use standardized modules and the HDM technology approach. The extended use of the standard modules, when applied as addressed in this study, will significantly reduce the problems associated with obsolescence, increase the MTBF, lower maintainer skill requirements, and enhance the economies of scale due to larger procurement quantities of fewer configurations of modules.

This study identified a number of stand-alone power supplies managed by U.S. Army Communication Electronic Command (CECOM). These power supplies are separately type classified and are authorized to PATRIOT and other systems on their respective Table of Organization and Equipment (TOEs). These power supplies incorporated 1970’s technology and are well within the HDM concept capability. Study results will be provided on an Internet website for consideration by CECOM and other DoD Elements for expansion of the technology throughout the services.

1.0 Introduction

This study is directed toward the standardization of high-density module (HDM) technology. High-density modules are pre-qualified commercial-off-the-shelf (COTS) DC to DC converters that are easily tailored for military and commercial use. They can be used as stand-alone plug-and-play converters or used as building blocks to allow the development of a wide range of power systems. Arrangements of multiple modules in series or parallel can be quickly configured into power micro-system for distributed or centralized power systems.

HDM power micro-systems are simple, cost-effective assemblies that provide the necessary functions for distributed power. The HDM DC to DC converters are manufactured with a wide range of input and output voltages with single or multiple outputs. They can operate in temperature ranging from -40^{o}C to 95^{o}C with an efficiency 780%. They can be designed with or without filtering and overload protection circuitry to meet almost any low voltage power requirements. The primary area considered in this study is the extension of the HDM technology from the PATRIOT to other DoD weapon platforms.

The Defense Standardization Program, as defined in DoD 4120.24-M (March 2000), identifies standardization criteria. Chapter 3, Paragraph C3.1 of that policy is paraphrased as follows:

> *"The program manager must balance the decision to standardize against specific mission requirements, technology growth, and cost effectiveness. Under the DoD's performance based acquisition policies, it is primarily the contractor's responsibility to recommend the use of standard materials, parts, components, and other items needed to meet performance requirements and satisfy other program elements, such as parts management and logistics support. However, interoperability, compatibility, and integration are key standardization goals that must be satisfactorily addressed for all acquisitions. These goals shall be specified and validated during the requirements generation process and throughout the acquisition life cycle."*

Standardization of a product or process is recommended when any of the following conditions exist:

A. There are multiple applications.
B. A product or technology is mature or stable.
C. Requirements do not change too rapidly.
D. There will be repetitive procurements.
E. There will be a cost benefit from economy of scale.
F. There is a need to limit or reduce items in the Federal supply system.
G. There are multiple suppliers.

H. There is a need to limit engineering practices.
I. There is a requirement for joint interoperability between systems or subsystems.

The relationship of each of these nine areas to system support cost is significant. Multiple applications (A) increase the number of base systems. The demands for the items are increased and these results bring about repetitive procurement (D). The increased need for the hardware brings the cost benefits of economy of scale (E) and also increases the profitability of producing hardware, which in turn, attracts multiple suppliers (G). When a product is mature (B), the requirement/design is not constantly or rapidly changing (C). This stability is reflected in spares availability across the various systems.

The engineering practices (H) are limited by reuse of the design approaches for more than one system. The leverage of using previous designs brings about a significant cost avoidance. The multiple use of spares results in a reduced number of lines in the Federal supply system (F). This sharing of the spare and repair parts between systems and services requires interoperability between systems (I).

Any of the above conditions can be a justification for standardization. The depth of application in each area varies; however all are directly related. The driver has been application of the concept to multiple systems, which is tied directly to repetitive procurements, economies of scale, multiple suppliers, reduced items in the Federal supply system and transport of engineering design. This study establishes the relationship of the HDM technology application to each of these areas.

When measured over its total life cycle, the operations and support (O&S) cost represents approximately 70% of the total life cycle cost (LCC) of an Army system. The research and development (R&D) and the investment (Procurement Army; PA) comprise the remaining 30%. The period of operation of a system reflects the time phase of the O&S cost stratification. The Army's new system acquisition approach utilizing performance specifications has reduced the R&D and PA dollar expenditures in various ways. As a result, emphasis toward savings has shifted to the O&S portion of the LCC. Any O&S cost reductions over time will be significant since the period for the O&S can exceed 20 years. Although annual reductions may be small, long-term savings in O&S cost are necessary in the current austere budget climate of the DoD. In addition, any LCC reduction efforts must ensure that fielded systems remain supportable while preserving high readiness states.

2.0 Purpose

The primary purpose of this project was to evaluate the feasibility of extending the application of the HDM power supply concept used on PATRIOT (PAC-3) to other weapon systems. The modular approach and the standardization of modules should allow other economies to be realized, such as avoidance of availability problems associated with loss of producers of components by increasing the module applications. As a result, the overall support cost for the system should be reduced while significantly increasing system reliability and availability. This approach is well suited for modernizing systems through direct replacement of spares with common HDM hardware. Power supply inventories can be replaced by attrition or at any desired phase-in rate. The operational costs will also be lowered by a reduction in the number of line items stocked as spares at all echelons where the HDM approach applies.

3.0 Background

The HDM power supply approach was initiated on the PAC-2 (PATRIOT) in an effort to standardize components, improve reliability, and avoid the effects of parts obsolescence. The initial analysis was an operations and support cost reduction (OSCR) action containing three (3) cited advantages: (1) Reduction of overall system power consumption; (2) Enhancement of unit readiness; (3) Simplification of the maintenance concept. Thus far, data on hardware test indicate all three advantages will be realized with the use of HDM technology. The approach was to take the current chassis and replace the existing electronics with the motherboard and HDMs. This approach allows the maintainer to change out the power supplies from the existing design to the new design without a change in replacement procedures. The modified units will then be placed in the system on an “as required” basis. This is proving quite successful on the PAC-3 (PATRIOT configuration). The inclusion of additional power supplies has established the feasibility of the approach on other hardware.

A market survey was conducted by the Auburn University Electrical Engineering Department in 1995 to establish the industry position in HDM technology. The vendors’ data from that study was revisited and is summarized in Paragraph 7.1. The analysis of available Commercial-Off-The-Shelf (COTS) capability and system needs during that timeframe also resulted in a contract being awarded to Rantec Microwave & Electronics, Inc. The purpose of this contract was to design and test HDM technology on the PATRIOT system. Paragraph 7.3 provides details of the current status of the PATRIOT HDM activity.

4.0 Approach

Specific Application:

The following methodology was used as general guidance in the course of this study:

A) PATRIOT, THAAD, MEADS, ARROW, NMD and JTAGS were the objective systems for the study, however, other candidates such as Black Hawk and Sentinel were explored as time and funding permitted.

B) The system power supplies were identified and power-conditioning requirements established. Power requirements were evaluated and compared to the HDM capabilities. The feasibility of the transition to the HDM approach was then established.

C) System/Power supplies that are viable candidates for the application of the HDM technology were identified and recommended. Available vendor's hardware that potentially met the system needs were identified (Table 7.3-3).

5.0 Study Methodology Used

A) Identified data sources (Paragraph 6.0)
   1) HDM Technology - Producers / Vendors
   2) System Requirements -System / Power supplies
   3) Reliability

B) Collected Technology Data (Paragraphs 7.1, 7.2)
   1) Sources
   2) Products
   3) Capabilities

C) Collected System Data (Paragraph 7.3)
   1) Power Supplies
   2) Power requirements

D) Collected Power Supply Requirements (Para. 7.3)

1) Input
2) Output
3) Environmental Conditions
4) Power Conditions

E) Compared HDM capabilities to the system / power supply requirements to determine candidate viability.
F) Prepared draft report and coordinated.
G) Prepared final report.

6.0 Major Data Sources

A) Army Commodity Command Standard System (CCSS)
B) Operation and Support Management Information System (OSMIS)
C) Related system/ hardware technical manuals (Supply and Maintenance)
D) Technical Data Packages (TDPs)
E) COTS Power Supply Selection; (dated October 23, 1995); prepared by Naval Sea Systems Command
F) COTS Manuals and Specification Sheets provided by HDM vendors.
G) HAYSTACK (Commercial Database)
H) Internet (Commercial Vendor Sources)

7.0 Findings

7.1 Market Survey

A power supply component market survey of existing commercial and military U.S. manufacturers was conducted. The Thomas Register, Electronic Engineers Master Catalog, worldwide web, Power Sources Manufacturing Association, and a list of producers that were already being used for AMCOM missile systems served as the primary data sources for the analysis. Key elements of the survey were versatility of application and reliability. Built-in test (BIT) and ease of maintenance of the assemblies were considered in the overall cost of using the commercial supplier approach. The power factor and power (watts) per cubic measure were also important features in the consideration of these sources. Some producers did not provide the mean time between failures (MTBF) but there were a number that indicated greater than 1 million hours and one stated a demonstrated MTBF greater than 5 million hours.

The market survey identified 114 companies that were requested to provide product data. Responses were received from all but 15 of the companies with data on their product lines. There were 22 companies that had military product lines and 77 were considered commercial hardware vendors. Those nonrespondant were assumed to be at a point in their business life cycle that they had no interest in military sales. The number of commercial hardware companies was reduced by eliminating those whose products were not in harmony with the selection criterion. More specifically, those producers with AC/DC converters only, automotive units, high voltage converters, non-modular products, low power (under 75 watts) and foreign companies were eliminated as candidate suppliers. A total of 21 companies remained after this screening. The military suppliers were screened using the same methodology as the commercial vendors and their number was reduced to 16. Each of the 16 military producers of HDM and 21 commercial companies were reevaluated. Tables 7.1-1 and 7.1-2 reflect their current contact information. Vendor data from these companies were used to develop the data provided in Paragraph 7.2. The performance capabilities and approach provided was considered typical of the industry in today’s market. The number of producers of the technology identified in the study that remain at this time reflects the concept of maturity and stability. This group is considered adequate for a comparison base without consideration of the new companies that have entered the market since the initiation of this approach.

MILITARY SUPPLIERS		
*Abbott Electronics, Inc.	(310) 202-8820	www.martekpowerabbott.com
*Airborne Power	1-800-777-4638 Ext. 383	www.powerparagon.com/ppi_airborn_power.html
Apex Microtechnology Corp	(520) 690-8600	www.teamapex.com
Arnold Magnetics Corp	(805) 484-4221	www.amcpower.com
ATC Power Systems, Inc	(603) 429-0391	www.atc.power.com
EG&G Power Systems	(626) 967-9521	www.egginc.com
Interpoint Corporation	1-800-822-8782	www.interpoint.com
Lambda Advanced Analog Inc	(408) 988-2702	www.lambdaaa.com
*Logitek Inc	(631) 567-1100	www.logitekinc.com
Modular Devices, Inc	(516) 345-3100	www.modev.com
Pico Electronics, Inc	1-800-431-1064	www.picoelectronics.com
Power convertibles Corp.	(520) 628-8292	cdpowerelectronics.com
Rantec Microwave and Electronics	1-800-596-6030	www.rantec.com
Raytheon Electronic Systems	(617) 984-8515	www.raytheon.com
ST Keltec Corp.	(850) 244-0043	No web page available
Vicor Corporation	(978) 475-6715	www.vicor.com
***-Indicates affiliation with another Company**		

Table 7.1-1. Military Suppliers

COMMERCIAL SUPPLIERS		
ACON, Inc	1-800-336-8022	www.acondc-dc.com
Astec America, Inc.	1-888-41ASTEC	www.astec.com
AT&T Microelectronics		www.AT&T.com
Cherokee International, Inc.	(714) 544-6665	www.cherokeellc.com
Computer Products, Inc	(703) 385-0966	www.computerproductsinc.com
Conversion Devices, Inc	(508) 559-0880	www.cdionline.com
Digital Power Corporation	(510) 657-2635	www.digipower.com
Electronic Measurements, Inc.	(732) 922-9300	www.emipower.com
*International Power Devices	(805) 987-8741	www.ipdconverters.com
International Power Sources	(508) 429-4440	www.intlpower.com
Intronics	1-800-367-0004	www.intronicspwr.com
Kepco, Inc	(256) 536-1506	www.kepco.com
Lambda Electronics, Inc	1-800-LAMBDA-4	www.lambda.com
*LZR Electronics, Inc	(763) 592-1900	www.lzrusa.com
Power One, Inc.-	(805) 987-8741	www.power-one.com
RO Associates, Inc.-	(408) 744-1450	www.roassoc.com
Tower Electronics, Inc	(612) 571-3737	www.towerinc.com
Tri-Mag, Inc	(559) 651-2222	www.tri-mag.com
Wall Industries, Inc	(603) 778-2300	www.wallind.com
Wilmore Electronics Co., Inc.	(919) 732-9351	
Zytec Corporation	(612) 941-1100	www.zytec.com
***-Indicates affiliation with another Company.**		

Table 7.1-2. Commercial Suppliers

Lastly, a representative company was chosen from each of the two groups. These representative companies have product lines typical of the industry and their approach to power supply requirements is in accord with that of current design approaches. Each of these companies has significant capabilities (depth) in the objective product lines. The selected companies produce HDMs that have a demonstrated reliability of greater than 800 thousand hours and 1 million hours MTBF, respectively. The advantages of these reliability levels are very apparent when introduced into the system availability calculations. Each of these producers has used the same design approach by introducing circuitry Built-In-Test (BIT) that will identify a failure in the system. They also utilized hardware that was designed to use a plug-in concept and a "motherboard" receiver. This plug-in approach, when coupled with the internal failure diagnostics, allows for a simplified maintenance concept. The standardization of the "mother board" and the plug-in concept allows the designer to provide a range of different output voltages and current levels with the same basic design while only changing the HDM modules to obtain the desired results. The use of "daughterboards" accommodates the commercial modules that would require an alteration of the plug-in arrangement. As a result of this design, the efficiency (input power vs. output power) of the units now exceeds 80%. Prior efficiencies varied from 50% to 65%. This reduction in power consumption provides two major economies. First, there is a reduction in heat generation and a resultant reduction in the weight and heat sink requirements. Second, there is an overall reduction in the input power needed to develop the same output level. As mentioned earlier, a self-diagnostic capability with an outside fault indicator would allow the maintainer to troubleshoot the system with much less training and the plug-in modules can be replaced at a forward area. The line replaceable unit (LRU) is changed from a complete power supply to a module that significantly reduces the pipeline cost for spares, as well as improves the repair time impact on system availability. If the load requirement is high and can be divided for a given power supply, and if multiple HDMs are used to provide the needed power, a failure of a single module will degrade the power supply but would not render it inoperative. This approach allows a system to remain in service, thereby increasing its overall availability. The problem with obsolete components is significantly reduced by module standardization. A higher demand due to multiple applications for repetitive procurements should make the production of the unit more profitable for the vendors; conversely, the loss of the profit base usually results in the producer discontinuing a product line.

7.2 Suppliers Capability / Approach

This study also included an assessment of the industry capability and approach to the HDM technology. Data from each of the selected companies was used in the analysis and is considered representative of the industry. The block diagram shown in Figure 7.2.1 depicts the approach and identifies the components needed to design a power supply for the desired output. This is the typical approach and its application will be expanded in the following paragraphs.

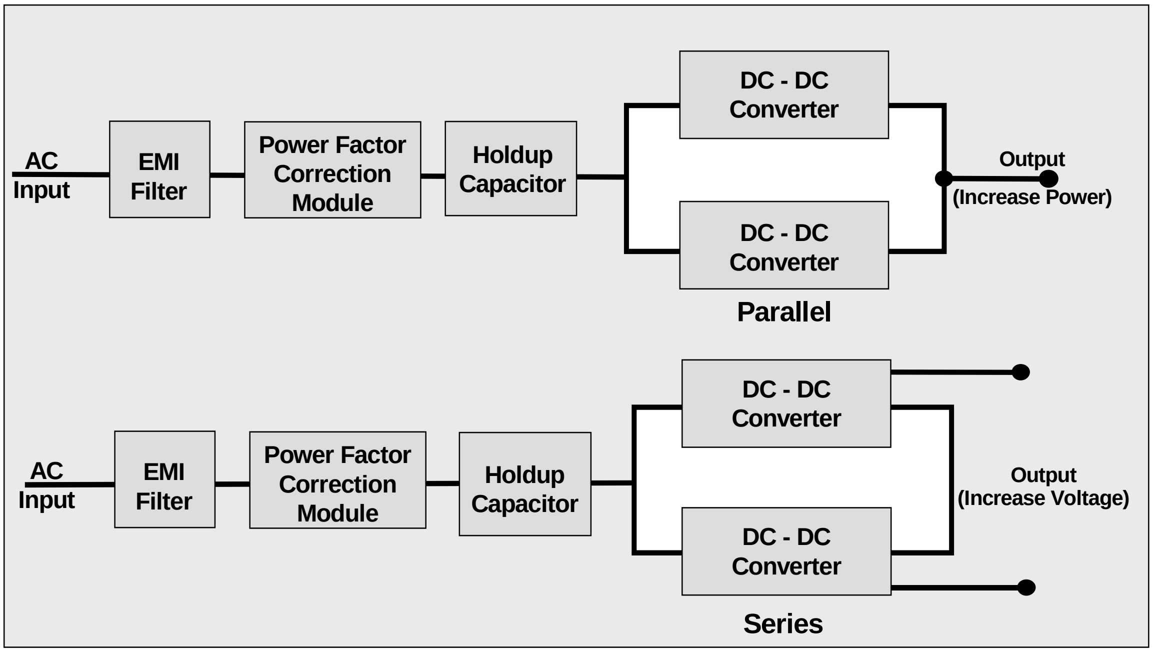


Figure 7.2-1. Basic Module Adaptation for Application

Figure 7.2-1 identifies the approach to increase voltage (series) and/or increase power (parallel). The EMI line filter is required to reduce emissions of the system to the FCC emission standards. The typical filter is rated at 125/250 volts AC with operating maximum current of 6.0 amperes. The unit discharge voltage after 60 seconds will be 34 volts maximum. These filters are plug-in type units and are readily adaptable to the overall requirements of the power supply design. The filter protects the power factor correction (PFC) module from external noise and prevents the switching noise generated by the PFC from creating problems externally.

An AC to DC Power Factor Correction Module is required in all power supplies where the primary input power is AC. The modules are produced in three standard configurations with capacities from 600 to 1200 watts. Table 7.2-1 provides the typical input and output for this element of the normal power supply.

	Input		Output
Configuration	Voltage Range	Frequency Range *	VDC
600 Watts	85 - 265	47 - 63Hz	380
1000 Watts	170 - 265	47 - 63Hz	380
1200 Watts	85 - 265	47 - 63Hz	380

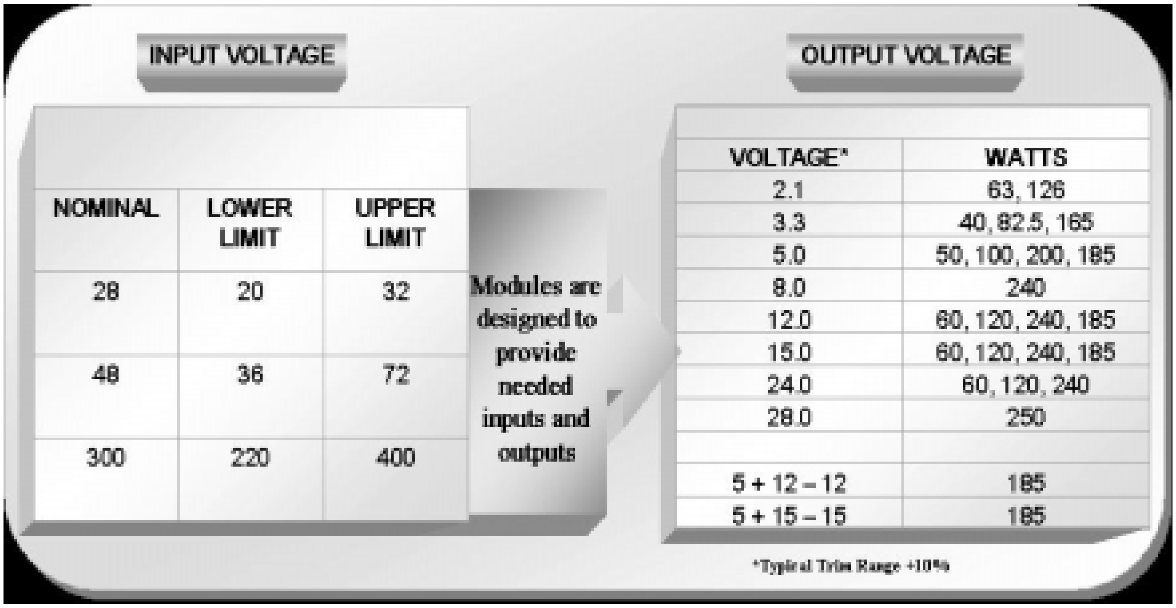
**Will Operate to 440Hz*

Table 7.2-1. Power Factor Module Characteristic

The power factor (relationship of input power to output power) of each of these modules is .99. These units also incorporate over-voltage, thermal, and short circuit protection.

The holdup capacitor is required for proper performance of the power factor correction module. The length of time the supply must be capable of running without input power determines the power holdup needs, with the typical time of 20 - 50 milliseconds (MS).

The DC-DC converter high-density modules are designed with 3 basic VDC input levels. The levels are 28, 48, 300 volts nominal. The modules are rated as single and triple output and grouped by wattage families. The watts per family are as follows: Single output; 50-60, 100-120, 200-250; Triple output: 185, (Figure 7.2-2).



INPUT VOLTAGE

NOMINAL	LOWER LIMIT	UPPER LIMIT
28	20	32
48	36	72
300	220	400

Modules are designed to provide needed inputs and outputs

OUTPUT VOLTAGE

VOLTAGE*	WATTS
2.1	63, 126
3.3	40, 82.5, 165
5.0	50, 100, 200, 185
8.0	240
12.0	60, 120, 240, 185
15.0	60, 120, 240, 185
24.0	60, 120, 240
28.0	250
5 + 12 – 12	185
5 + 15 – 15	185

*Typical Trim Range +10%

Figure 7.2-2. DC – DC Converter Module (Inputs and Outputs)

The modules are building blocks and may be connected in parallel to provide higher current rates or connected in series to increase the output voltage. An example of this application is a needed output of 28 volts @ 25 amperes. This would require the parallel connection of three 28VDC 9 amperes modules providing a total of 27 amps available power output.

7.3 Missile System Level Data

For this study, the primary systems under consideration were PATRIOT (PAC-2 and PAC-3), THAAD, MEADS, NMD Radar, ARROW, and JTAGS. Black Hawk and Sentinel were also reviewed. The available data in OSMIS as well as basic logistical documentation on the various systems resulted in the information presented in Table 7.3-1. The table depicts the quantity of different power supply models that required consideration under the study effort.

HDM			
POWER SUPPLY CANDIDATES			
System / End Item	**Qty. Different Models**	**System Density**	**Remarks**
ARROW	N/A	N/A	Documentation Not Available See Para. 7.3.6
Black Hawk	8	1259	See Para. 7.3.7
JTAGS	N/A	N/A	Documentation Not Available See Para. 7.3.4
MEADS	N/A	N/A	Documentation Not Available See Para. 7.3.5
NMD / RADAR	N/A	N/A	Documentation Not Available See Para. 7.3.3
PATRIOT	20	54	See Para. 7.3.1
Sentinel	14	108	See Para. 7.3.7
THAAD	N/A	N/A	See Para. 7.3.2
BMC3I	8	N/A	
GBR	25	N/A	
Launcher	11	N/A	
Total	86		
(N/A - Not Available)			

Table 7.3-1. HDM Power Supply Candidates

The ARROW is fielded, and the NMD/RADAR and the MEADS are not in a life cycle development position where the power supplies can be identified at this time. In these situations, the prime developer (vendor) should be requested/encouraged to use the HDM technology in their system-level development effort. The OSMIS data file identified a number of stand alone power supplies used in the PATRIOT program as well as similar power supplies that are used in many other systems. They are managed by CECOM and each appeared to be older vintage units. The multiple applications of this hardware offer a significant increase in the densities to be considered. Examples of the varied application of these units are provided in Table 7.3-2.

Power Supply - PP6224/U		
AN/TRC-138B AN/TRC-173 APACHE AN/TRC-174 BLACK HAWK CAYUSE	CHINOOK COBRA HUEY KIOWA MOHAWK	PATRIOT QUICK FIX SEMINOLE TARHE TD-1234(P)/ TTC
Power Supply - PP-2953/U		
AN/TSC-116 AN/TYQ-138 42(V) 2 AN/TRC-138 AN/TRC-173 AN/TRC-174 APACHE BLACK HAWK	CAYUSE CHINOOK COBRA GUARD RAIL HUEY KIOWA	PATRIOT QUICK FIX SEMINOLE MOHAWK TARHE RO

Table 7.3-2. Power Supply Applications

Table 7.3-3 illustrates the proposed HDM requirements for the systems indicated. This table identifies the multiple potential users of specific modules. This data should expand as additional systems incorporate the technology.

Family of HDM Modules for PEO-AMD Systems									
			HDM Modules *						
System	**Power Supply Quantity Per Fire Unit**	**Fire Units**	**301**	**302**	**303**	**305**	**308**	**302T**	**Other**
PAC 2	137	54	X	X	X	X		X	
PAC 3	76	54		X	X		X		X
THAAD	44	8	X		X	X			X
MEADS	100**	18	X		X		X		X
***Based on Rantec Modules**									
**** Estimated**									

Table 7.3-3. HDM Modules Application Matrix

7.3.1 PATRIOT Power Supplies

The PATRIOT surface launched air defense missile system is a long range, all altitude, all weather system fielded to defeat advanced aircraft, tactical ballistic missiles (TBMs), and cruise missiles. PATRIOT is capable of engaging multiple simultaneous targets in advanced electronic countermeasure (ECM) conditions and is interoperable with Hawk and other air defense systems. A PATRIOT battery (that is, the basic firing unit) consists of a phased-array radar, an engagement control station, computers, and up to eight launchers, each of which holds four (4) ready-to-fire missiles.

Major System Components:

Radar

The AN/MP1-53 phased-array radar carries out search, target detection, target track, identification, missile tracking, missile guidance, and electronic counter-countermeasure (ECCM) functions. The phased-array radar is mounted on a trailer and operates in an automated fashion.

Engagement Control Station

The AN/MSQ-104 Engagement Control Station is the only manned station in a PATRIOT Fire Unit and provides the human interface for control of the automated functions. The Control Station communicates with the M901 Launching Stations, with other PATRIOT Fire Units (i.e., other PATRIOT batteries) and the higher command headquarters.

M901 Launching Station

The M901 Launching Station transports, points and launches the PATRIOT missile. Each launcher has four missiles. The launcher is remotely operated via a VHF data link or fiber optic data link from the engagement control station, which provides both the missile pre-launch data and the fire command signal. The Launching Station is equipped with an electrical power unit, a data link terminal module, a launcher electronics module, and the four canisters with missile. The launcher is trailer-mounted and holds four PAC-2/GEM missiles or 16 PAC-3 missiles in canisters. Each PATRIOT fire unit may consist of as many as 8 launchers.

PATRIOT OSMIS

The PATRIOT OSMIS data identified five stand-alone power supplies that are used with the system. These power supplies are managed by CECOM and have multiple applications. Therefore, they should be identified as potential candidates for the HDM modernization. Changes to this hardware would impact all users as identified previously in Paragraph 7.3. These units are listed in Table 7.3-4 along with the fifteen AMCOM managed items.

PATRIOT Power Supplies								
Part Number	**Function**	**Cage Code**	**Item Mang.**	**National Stock Number**	**Price**	**Intput**	**Output**	**Remarks**
				AMCOM				
RADAR								
11457668	Digital 1	04971 *	B64	6130-01-109-6577	$ 8,747.00	208 VAC 400 Hz	5V 30 A	
10273546	Digital 2	04971	B64	6130-01-091-6748	$ 8,588.00	208 VAC 400 Hz	5V 60 A	
11457669	Digital 3	04971	B64	1430-01-102-4349	$ 9,119.00	208VAC 400 Hz	5V 140 A	
10273548	Analog 1	04971	B64	6130-01-092-0780	$ 17,858.00	208VAC 400 Hz	12.6-16.6 V 4 A Max	
10273549	Analog 3	04971	B64	6130-01-092-5948	$ 6,461.00	208VAC 400 Hz	12.6-16.6 V 20 A Max	
10273551	Analog 5	04971	B64	6130-01-092-0776	$ 9,371.00	208VAC 400 Hz	19-23 V 13 A Max	
10273552	Analog 6	04971	B64	6130-01-091-6746	$ 13,255.00	208VAC 400 Hz	15.1 V 33 A	
11466636	Antenna 1	18876	B64	6130-01-274-8484	$ 15,138.00	208VAC 400 Hz	12.3V 20 A	
11447530	Antenna 2	04971	B64	6130-01-093-3444	$ 19,358.00	208VAC 400 Hz	3, -70 V 24/ .75 A	
10273555	Misc. 1	04971	B64	1430-01-092-0633	$ 7,443.00	208VAC 400 Hz	28 V 20 A	
10273557	Misc. 2	04971	B64	6130-01-092-0775	$ 5,522.00	208VAC 400 Hz	28V 8A	
10273559	Misc. 3	04971	B64	6130-01-092-0777	$ 4,757.00	208VAC 400 Hz	5, -+ 12.6V 10, 1 A	
11462253	Exciter	05716 **	B64	1430-01-139-9738	$ 88,279.00	208VAC 400 Hz	5 V 8 A; 9 V 2 A; 10 V .5 A; 28.5 V 14 A; -32 V 1 A	
11444734	2.2 Volt	04971	B64	6130-01-092-0778	$ 4,061.00	208VAC 400 Hz	2.2 V 13 A	
LAUNCHER								
11450561-1	Launcher	04971	B64	1440-01-116-0275	$ 1,616.00	208VAC 400 Hz	28 V 20 A	
				CECOM				
PP-1104/M	P/N 12A28CDSOD	97520	B16	6130-00-542-6385	$ 799.00	N/D	N/D	LIN P37218 Stand alone units
PP-2309/M	P/N 0376-746	12867	B16	6130-01-139-2514	$ 1,131.00	N/D	N/D	LIN P38314 Stand alone units
PP-2953/M	CAGE 80058	18038	B16	6130-00-985-7899	$ 1,669.00	N/D	N/D	LIN P38588 Stand alone units
PP-4763/M	P/N BS030-50PPY2	02994	B16	5820-00-937-7690	$ 1,637.00	N/D	N/D	LIN P40745 Stand alone units
PP-6224/M		80058	B16	6130-00-133-5879 R/B	$ 1,669.00	N/D	N/D	LIN P40750 Stand alone units
			B16	6130-01-223-0267				
		*** Rantec**				**N/D No Data**		
		**** Raytheon**						

Table 7.3-4. PATRIOT Power Supplies

All except two of the AMCOM units (Antenna 1, Exciter) list Rantec as a producer. There are five of the power supplies already in the development phase of conversion to HDM. The five are Digital 2, Digital 3, Antenna 1, MISC 1 and Launcher. The MISC 1 and the Launcher are identical power supplies except for the connection. Since the individual tests of the five units are nearing completion, the next step in the ongoing program is to enter into a system level operational test with all five power supplies installed. Since the reliability for the system will be established based on the MTBF, all indications are that the HDM modules will significantly increase overall system reliability.

The five power supplies that are currently under evaluation constitute a requirement for only three different modules. The incorporation of the HDM technologies will reduce the lines stocked in the Authorized Stockage List (ASL) and Prescribed Load List (PLL) for this purpose by 40% and eliminate the rebuild/depot program for all five power supplies. The actual cost reduction associated with the ASL and PLL line reduction should be much greater than 40% because of the difference in the price of a complete power supply vs. a single module. These cost savings are not a part of this study but are used for basic justification of the final recommendation/considerations.

If the HDM technology is extended to all PATRIOT power supplies, initial analysis indicates there would be a requirement for four additional modules for a total of seven modules to support the fifteen different power supply requirements. This would represent a greater than 50% reduction in the number of lines stocked in the ASL and PLL for this purpose.

The increase in reliability of the units should have a significant impact on the availability of the system. The HDM units are estimated to double the MTBF of the power supplies and therefore would significantly improve system readiness. The change in logistics, maintenance, repair parts, and training would produce a 30% to 40% cost avoidance related to the power supplies. The built-in test capability of the modules would also reduce the maintainer's skill requirements. The original HDM effort was directed toward four different power supplies. They were the Digital 2 (10273546), Digital 3 (11457669), Antenna 1(11466636) and the MISC 1 (1027355). This data supported the integration of the technology into this first quantity of PATRIOT power supplies. The final system-level validation of the approach is the only remaining hurdle for the program to overcome. Once this is complete, a total implementation plan will be generated which will define quantities and approaches to system modification.

The PATRIOT electrical power supply performance envelope is shown in Figure 7.3-5 below. All PATRIOT power supplies are single or dual output except the Exciter, which has a requirement for seven different voltages; however, the wattage of this assembly is low.

OUTPUT REQUIREMENT			
	VOLTAGE	**AMPERES**	**WATTS**
LOW	-32	.75	5
HIGH	28	140	700

Table 7.3-5. PATRIOT Power Supply Performance Envelope

7.3.2 Theater High Altitude Area Defense System (THAAD)

The THAAD system is comprised of mobile launchers, missile interceptors, radar, and battle management/command, control communications, computers, and intelligence (BM/C4I) units. The launch system is a modified U.S. Army palletized loading system truck that is equipped with a missile-round pallet. The interceptor consists of a single-stage, solid-fuel booster which employs thrust vector control technology for boost-phase steering, and a separating kill vehicle that uses an infrared seeker and divert thrusters for terminal guidance and control. The THAAD radar is a solid-state, X-band, phased-array antenna that performs early warning, threat-type classification and interceptor fire-control functions. As the communications link between the BM/C4I and interceptors, it also delivers navigational information to the kill vehicle that is used for mid-course guidance. The THAAD BM/C4I segment manages and integrates all THAAD components to control the THAAD weapon system. Its major components are the Tactical Operations Center, the Sensor System Interface, and the Communications Relay, which are transported on High Mobility Multi-Purpose Wheeled Vehicles.

The design of the system is stable enough to establish a logistics database. As of the study date, provisioning actions have not been completed. The logistics data was used to identify the power supplies for each major item as indicated in Table 7.3-6. The requirements were tied to the vendors listed in Table 7.3-7. The available data, even though very limited, indicates the output requirements are very close to those established for the PATRIOT system (Table 7.3-5), while the pattern reflects the power supply industry standard outputs. The study research indicates that the HDM technology may have been considered/applied in some areas of the design. System requirements and power supply application data are limited; therefore an individual hardware assessment is not possible.

The THAAD System has been procured under the new acquisition guideline (performance specification); therefore, there will be no deliverable technical data package (TDP). Under this approach, the prime vendors are tasked to control the configuration and provide the support needed for the system. Based on this established position, the THAAD-specific study recommendation will be limited.

THAAD Power Supplies							
Part Number	Cage Code	Item Mang.	National Stock Number*	Price	Input	Output	Remarks
BM/C3I							
28-1414100-1 (SPS3912)	82877 (09004)	**	6130-01-391-9049	$ 15,785.44	**	**	
414282-100	13973	**	DCAA01GA16AA	**	**	**	
28-2753645-1	67032	**	DCAA23AA	**	**	**	
246300-100	13973	B64	6130-01-308-8898	$ 12,295.12	**	25 VDC	
12CMDF13A	31557	**	DCAA29AA	**	**	**	
197087-101	13973	**	7021-01-099-4766	$ 11,165.67	**	12 VDC	Descrete Components
414218-100	13973	**	DCBH17	**	**	28 VDC	
MG1211-6AMR	0D6P8	**	DCBH25AD	**	**	**	
TRANSPORTER/ LAUNCHER							
1A24218	5D177	**	DBAD07	**	**	**	
1A28296	5D177	**	DBAD07AF	**	**	28 VDC	
1A25172	5D177	**	DBAD07AG	**	**	12 VDC	
1A25265	5D177	**	DBAD07AH	**	**	24 VDC	
1A24637	5D177	**	DBAD12	**	**		
1A24209-101	5D177	**	DBBD01AB	**	**	5/15 VDC	
1A24209-102	5D177	**	DBBD01AG	**	**	28 VDC	
1A24209-103	5D177	**	DBBD01AH	**	**	20 VDC	
1A24209-104	5D177	**	DBBD01AJ	**	**	10 VDC	
1A24209-105	5D177	**	DBBD01AK	**	**	-20 VDC	
1A25253	5D177	**	DBAD10	**	**	**	
GBR							
414282-100	13973	**	DEAA09	**	**	**	
28-2753645	67032	**	DEAA10	**	**	**	
G674016-50	49956	**	DEAB02	**	**	24/12 VDC	
G603425-3	49956	**	DEBA38	**	**	**	
G603425-5	49956	**	DEBA39	**	**	**	
G603425-6	49956	**	DEBA40	**	**	**	
G603425-7	49956	**	DEBA41	**	**	**	
G603425-5	49956	**	DEBA45	**	**	**	
2T-SPPWR-SV	15476	**	DEBB0107	**	**	**	
30-36010-01	15476	B16	6130-01-388-6639	$ 1,116.08	48 VDC	-12VDC; -5VDC	
30-36009-01	15476	B16	6130-01-388-6665	$ 1,468.69	48VDC	5.1 VDC; 12 VDC	
H7869-AK	15476	FFZ	6130-01-340-3110	$ 1,526.83	**	**	
29-28103-01	15476	S9G	6130-01-433-8655	$ 764.20	**	**	
30-37197-02	15476	**	DEBC020401	**	**	**	
H7890-MA	15476	**	6130-01-407-5835	**	**	**	
7026441	29381	**	DEDB31	**	**	**	UPS
8306A-1	0DRX0	**	DEDB3101	**	**	**	
H7819-AA(SL5805-2-125-193)	15476(HDG29)	FFZ	6130-01-388-7816	$ 1,036.82	**	**	
42048 II	53158	**	DEDB	**	**	**	
6033740-1	29381	**	DEFA07	**	**	**	
6033741-1	29381	**	DEFA09	**	**	**	
LRS-49-5 (75001835)	80103 (64869)	S9G	6130-01 381-0207	$ 177.00	**	**	
TBD/IFPS	49956	**	DEBB040406	**	**	**	
30-32606-03	15476	**	DEBB020105	**	**	244W	
705522-2 (658/1/04558/001)	54418 (U2982)	**	6130-01-387-1783	**	**	**	
*** LCN used when item not cataloged ** No other data available**							

Table 7.3-6. THAAD Power Supplies

THAAD Power Supply Producers List			
CAGE	**Company**	**Address**	**Phone Number**
13973	Litton Systems Inc. Data System Div.	29851 Agoura Rd. Agoura,CA 91376-6008	(818) 991-9660
15476	Compaq	111 Powdermill Rd. Maynard, MA 01754	(978) 493-5111
29381	Gichner System Group Inc; Gichner Shelter System Div.	490 E. Locust St. POB 481 Dallastown, PA 17313-0181	(717) 246-5465
31557	Natel Engineering Co. Inc. Power Cube Div.	9340 Owensmouth Ave. Chadsworth,CA 91311	(818) 734-6547
49956	Raytheon Co. Executive Offices	141 Spring St. Lexington,MA 02173	(915) 771-5374
53158	Proctor International Inc.	15050 N E 36th St. Redmond, WA 98052-5317	(425) 881-7000
54418	MILTOPE Corp.	500 Richardson RD. S Hope Hull, AL 36043	(334) 613-6391
64869	FLIR Systems Inc.	16505 SW 72nd Ave. Portland, OR 97224-7705	(503) 684-3731
67032	GTE Government System Corp. Communication System Div.	400 John Quincy Adams Ave. Tauton,MA 02780-1069	(508) 880-4157
80103	VEECO Instruments Inc. Lambda Div.	515 Broad Hollow Rd. Melville, NY 11747-3703	(516) 694-4200
82877	ROTRON Inc. DBA ROTRON Technical Motor Div.	9 Hasbrouck Ln. Woodstock, NY 12498	(914) 679-2401
09004	Transistor Device Inc.	85 Horsehill Rd. Cedar Knolls, NJ 07927-2003	(973) 267-1900
5D177	Lockheed Martin Corp Lockheed Martin Missile And Space	4800 Bradford Dr. 1103 West Station Huntsville, AL 35807	(408) 742-3816
OD6P8	H C Power Inc.	1733 Alton Pky Irvine, CA 92606-4901	(714) 261-2200
ODRXO	Deltec Co.	12160 Gridley Rd. Norwalk, CA 90650	(213) 929-1775
U2982	British Aerospace Defense System	Grange Road Christchurch, Dorset UK	01202-486344

Table 7.3-7. THAAD Power Supply Producers List

7.3.3 National Missile Defense System

The NMD system will be a fixed, land-based, non-nuclear missile defense system with a space-based detection system consisting of three elements to respond to a ballistic missile directed against the United States:

- Ground Based Interceptors (GBIs)
- Battle Management, Command, Control, and Communications (BMC3), which includes:
  - Battle Management, Command, and Control (BMC2), and
  - In-Flight Interceptor Communications System (IFICS)
- X-Band Radars (XBRs)

The GBI is the “weapon” of the NMD system. Its mission is to intercept incoming ballistic missile warheads outside the earth’s atmosphere (exoatmospheric) and destroy them by force of the impact. During flight, the GBI is sent information from the NMD BMC2 through the IFICS to update the location of the incoming ballistic missile, enabling the GBI onboard sensor system to identify and home-in on the assigned target. The GBI element would include the interceptor and associated launch and support equipment, silos, facilities, and personnel. The GBI would be a dormant missile that would remain in the underground silo until launch. Launches would occur only in defense of the United States from a ballistic missile attack.

The NMD Battle Management, Command and Control (BMC2), a subelement of the BMC3 element, is the “brains” of the NMD system. In the event of a launch against the United States, the NMD system would be controlled and operated through the BMC2 subelement. The BMC2 subelement provides extensive decision support systems, battle management systems, battle management displays, and situation awareness information. Surveillance satellites and ground radars locate targets and communicate tracking information to battle managers, which process the information and communicate target assignments to interceptors. The BMC2 subelement operations would consist mostly of data processing and management functions associated with the NMD system and function as the centralized point for readiness, monitoring, and maintenance.

The NMD In-Flight Interceptor Communications System (IFICS) is a subelement of the BMC3 element and would be geographically distributed to ground stations that provide communications links to the GBI for in-flight target and status information between the GBI and the BMC2. Up to 14 IFICS (7 pairs) would be required to support the NMD system. The IFICS would consist of a radio transmitter/receiver enclosed in a 5.8-meter (19-foot) diameter inflatable radome adjacent to the equipment shelters.

The X-band / Ground Based Radars (XBR) would be ground based, multi-function radars. For NMD, they would perform tracking, discrimination, and kill assessments of incoming ballistic missiles. The radars use high frequency and advanced radar signal processing technology to improve target resolution, which permits the radar to more accurately discriminate between closely-spaced objects. The radar would provide data from earlier phases of a ballistic missile’s trajectory and real-time continuous tracking data to the BMC2. The site would include a radar mounted on its pedestal and an associated control and maintenance facility, a power generation facility, and a 150-meter (492-foot) controlled area.

7.3.4 Joint Tactical Ground Station (JTAGS)

The Joint Tactical Ground Station (JTAGS) is the transportable, in-theater element of the U.S. Space Command's Tactical Event System (TES) and will provide Theater Commanders with a capability to process data and disseminate warning of Tactical Ballistic Missile (TBM) launches. JTAGS processes data from Defense Support Program (DSP) satellites in stereo (using two satellites). JTAGS ties directly to theater communications systems to disseminate TBM positional information to support air defense artillery cueing, early warning of units in the impact area, and targeting requirements.

A JTAGS section includes a shelter equipped with satellite receivers, processors, displays and communications interfaces. Each JTAGS section has three portable eight-foot dish antennas. A JTAGS shelter is 8x8x20 feet powered by either tactical generators (60KW) or commercial power, if available.

A JTAGS section is manned by an Army/Navy team of about 15 personnel and is deployed in-theater as a detachment of two sections. JTAGS is capable of supporting worldwide contingencies and training exercises. The JTAGS is a non-developmental item (NDI). It is primarily a commercial-off-the-shelf (COTS) and Government-off-the-shelf (GOTS) system. The approaches used in this type program do not lend themselves to a standardization process like the HDM technology. In this area, the prime vendor should be provided a description/technical data on the existing standardized modules and encouraged to use the existing designs where possible in new systems.

7.3.5 Medium Extended Air Defense System (MEADS)

The Medium Extended Air Defense System (MEADS) will be a highly mobile, low to medium air defense system designed to replace the HAWK and PATRIOT PAC-3 air defense system. It will be a key element of the theater missile defense in the Army Air and Missile Defense architecture. The MEADS weapon system is needed to provide protection of maneuver forces. The system will provide area and point defense capabilities against both tactical missiles, which include tactical ballistic, air-to-surface, and anti-radiation missiles; and air-breathing threats, which consist of fixed- and rotary-wing aircraft, cruise missiles, and unmanned aerial vehicles. The system will consist of a sensor, launcher, missile, and tactical operations center and will be capable of autonomous operations.

The MEADS battalion will consist of three firing batteries and a headquarters battery. Each battery will have nine launchers controlled by a battery tactical operations center. Each launcher will be equipped with eight hit-to-kill missiles. Two radars, an X-band fire control radar, and a low-frequency surveillance radar will be intrinsic to the MEADS battery.

The MEADS initiative is so early in the developmental phase that no firm design is available. The system concept (partner countries) does not lend itself to outside influences.

7.3.6 ARROW Weapon System

The ARROW Anti-tactical Ballistic Missile Program is a joint US/Israel effort and is being developed by Israeli companies (Israel Aircraft Industries, RAFAEL, Military Industries, and MALAN Industries). The system is comprised of the “Green Pine” Radar, “Citron Tree” BMC3, “Hazel Nut” Launch Control, ARROW Missile and common equipment. The Project Manager, PEO Air and Missile Defense is responsible for the overall deployability of the system. This includes research, development, and evaluation of the missile, launcher and the functional integration of the system including the radar. The nature of this system, (i.e., designed and built by Israel and its internal contractors) does not allow an evaluation of the power supplies therein. Actions on the infusion of HDM technology will only be recommended and the data associated with U.S. HDM activities provided.

7.3.7 Black Hawk

The UH60 is the Army’s most versatile utility helicopter that can be equipped with weapons. There are at least seven models in service of which the Army’s inventory exceeds 1200. They are used for executive transportation, electronic warfare, ambulatory services, and special forces. The primary electrical power sources are from an engine-driven alternator on each engine. The output is 115/200 VAC, 30/45 KVA, 400Hz and three (3) phases. The auxiliary power unit (APU) provides 115/200 VAC, 20/30 KVA, 400 Hz and three phases. Power distribution/requirements are dependent upon the equipment being used on the basic aircraft.

The Black Hawk system was reviewed for power supply requirements. OSMIS identified those shown in Table 7.3-8.

Black Hawk Power Supplies							
Part Number	Cage Code	Item Mang.	National Stock Number	Price	Intput	Output	Remarks
LPD-422A-FM	80103	B17	6130-01-008-3874	$ 42.61	105-132 VAC	0-80 VDC	
					47-440 Hertz		
DC-30-40FP	OM4E9	S9G	6130-00-249-2748	$ 2,993.64	207-253 VAC	0-40 VDC	
259373	82577	*	*	*	57-63 Hertz	0-30 Amperes	
6101-4030	61987	*	*	*	12 Amperes	*	
6101A-4030	61987	*	*	*	*	*	
6268B	28480	*	*	*	*	*	
60-2977-5	72914	B17	6220-01-115-9237 R/B	$ 2,021.00	*	*	
60-2977-5	72914	B17	6220-01-211-6790	*	*	*	
70553-05002-110	78286	*	*	*	*	*	
PP2953/U	18038	B16	6130-00-985-7899	$ 1,669.00	*	*	Duplicated on the Huey
	80058	*	*	*	*	*	
PP1451G	80058	B16	6130-01-985-8157	$ 784.00	115-230 VAC	28-56 VDC	
						8 Amperes	
PP6224/U	80058	B16	6130-00-133-5879 R/B	$ 1,669.00		27 Amperes	Duplicated on the Huey
A3057765	80063	B16	6130-01-223-0267	*	*	*	
PP6224B/U	80058	*	*	*	*	*	
500101	52512	*	*	*	*	*	
AM4316A/GRC-103CV	80058	B16	6130-01-053-6391	$ 10,966.04		26;12;-12 VDC	RF converter Not a canidate
SM-E-763663	80063	*	*	*	*	*	
			Replaces:				
AM4316GRC-103V	80058	B16	5820-00-824-0833	*	*	*	
407-131-1	90073	B16	6130-01-064-1841	$ 24,873.00	*	*	RF converter Not a canidate
* Data Not Available							

Table 7.3-8. Black Hawk HDM Candidates

7.3.8 Sentinel

The AN/MPQ-64 Sentinel is a modular, mobile air defense surveillance radar that provides early warning target data to short and medium range air defense weapons. Two of the radar's most important features are the ability to measure target positions in three dimensions and low ECM susceptibility. Both qualities are attributable to the incorporation of a narrow, pencil beam output with low side lobes that rapidly scan the air space for targets and accurately track their position while avoiding jamming sources. The radar incorporates a Mark XII identification friend or foe system along with a 5-degree backscan to identify and establish accurate 3 dimensional target track files. The X-band radar covers 360 degrees azimuth and a 22 degrees elevation look angle within –10 to +50 degrees. It can detect hovering aircraft and identify/track 60 or more targets simultaneously.

The Sentinel system was reviewed for HDM power supply candidates. Table 7.3-9 identifies the Sentinel candidates.

Sentinel Power Supplies							
Part Number	**Cage Code**	**Item Mang.**	**National Stock Number**	**Price**	**Input**	**Output**	**Remarks**
SM-A-803054-2	05869	B16	6130-01-378-6729	$ 610.54	15	3.1 A	
	80063	*	*	*	*	*	
Alt. P/N 5626A1-15-3-1	03526	*	*	*	*	*	
SM-A-803056-2	05869	B16	6130-01-072-1531	$ 154.00	24	5A	
	80063	*	*	*	*	*	
Alt P/N A3211264	80063	*	*	*	*	*	
Alt. P/N 5623A-24/5-100	03526	*	*	*	*	*	
SM-A-803058-2	05869	B16	6130-01-378-5732	$ 847.49	28	17A	This item has indicated it may be a high failure item
	80063	*	*	*	*	*	
Alt. P/N 5737A1-28-17	03526	*	*	*	*	*	
SM-A-803058-1	05869	B16	6130-01-072-1532	$ 1,097.26	5	60A	
	80063	*	*	*	*	*	
Alt P/N A3211212	80063	*	*	*	*	*	
Alt. P/N 5737A1-5/50-100	03526	*	*	*	*	*	
SM-A-803050-5	80063	B16	6130-01-091-7767	$ 1,284.04	Dual	*	
Alt P/N A3211155	80063	*	*	*	*	*	
Alt. P/N 5624A-1-D-100	03526	*	*	*	*	*	
SM-A-800069-1	80063	B16	6130-01-088-6692	$ 2,223.34	15	*	
Alt. P/NWW15DX4-20	15755	*	*	*	*	*	
SM-A-800067-1	80063	B16	6130-01-088-6690	$ 480.32	210,230	*	Have had a problem with one producer of this item
FD220.0-0.050	13850	*	*	*	*	*	
SM-C-800908-1	80063	B16	6130-01-089-3565	$ 987.32	250	*	
Alt. P/N 11-100-0134	30882	*	*	*	*	*	
SM-A-800071-1	80063	B16	6130-01-117-7171	$ 435.49	*	*	
Alt. P/N 7785-D01	09062	*	*	*	*	*	
13458746-001		B64	6130-01-434-1214	$ 21,272.22	5	*	Unique
13458754-001		B64	6130-01-434-1215	$ 14,325.15	5	*	Unique
SM-A-803054-1	80063	B16	6130-01-072-1529	$ 596.95	*	*	
	05869	*	*	*	*	*	
Alt. P/N 5626A1-517.5-100	03526	*	*	*	*	*	
R/B 30807PS	07388	B16	6130-01-378-1712	$ 596.95	*	*	
SM-D-803267	80063	B16	6130-01-093-0263	$ 9,068.37	*	*	
Note: Those not marked unique are also used on the FIREFINDER * Data not available							

Table 7.3-9. Sentinel HDM Candidates

All Sentinel units are managed by CECOM except for two power supplies that are managed by AMCOM. The two are part numbers 13458746-001 and 13458754-001. These power supplies are well within the capabilities of the HDM application and definitive performance requirements of the two units are reflected in Figure 7.3-3. Figure 7.3-4 is an electrical schematic of the proposed HDM design. These power supplies are for a (VME) chassis and are physically single slot configurations. The HDM industry has a VME single slot series that could possibly replace the unit with very little modification.

	Input		Output	
Part No.	Voltage	Frequency	VDC	Amperes
13458754	115VAC ± 15%	400Hz	+ 5	6
			- 5.2	4
			+15	1
13458746	115VAC ± 10%	400Hz	+ 5	30
			+12	2
			-12	2

Figure 7.3-3. Sentinel Power Supply Requirements

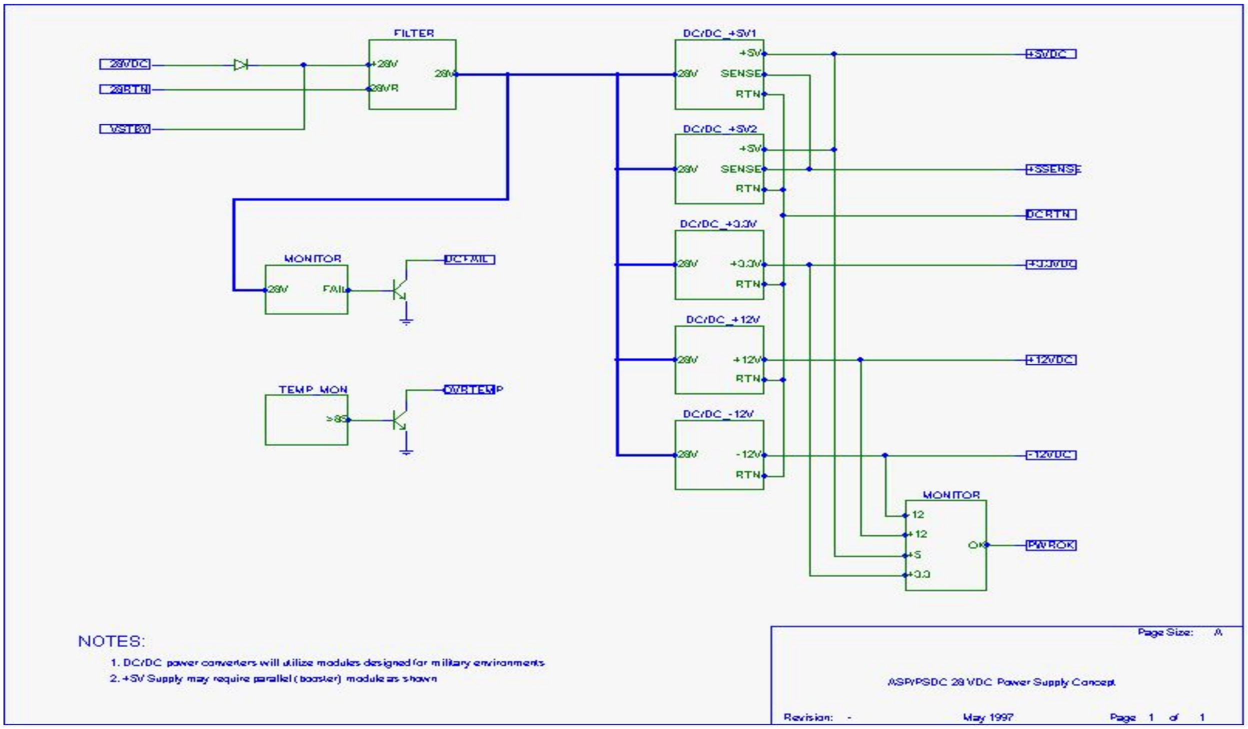


Figure 7.3-4. Proposed HDM Schematic
(13458746-001 / 13458754-001)

8.0 Conclusion

The HDM technology is now mature and should be used on all new and modified systems. Any power supply that was designed with discrete components, especially those with items approaching obsolescence, should be a candidate for replacement. The building block concept allows versatility and adaptability of the new design. The electrical design can be exported from one system to another even when the actual power supply physical configuration requires change. The interchange of modules will result in a significantly lower cost for supply stockage of spares as well as reducing repair time/maintenance downtime. Also, the increase in reliability will provide a significant improvement in the end item availability. The Built-In-Test (BIT) self-diagnostics and plug-in concept will improve the maintenance process and reduce the training requirement for the maintenance technician. The repair forward concept will abolish the depot rebuild program and eliminate the Depot Maintenance Work Requirement (DMWR).

The only negative aspect of the infusion of this technology is the need for redesign and test with its associated cost; however, in most cases the cost can be recovered in a relatively short time. All efforts should include a complete economic analysis to insure expected system life and lifetime performance savings will justify the changes.

This study was the first initiative of a technical data search since the change in the deliverables to the Government. The PATRIOT program was developed under the old acquisition guidelines and technical data is available, however, all the newer systems are being developed without the delivered TDP. Such actions introduce a significant handicap when seeking technical data on system requirements.

In conclusion, the use of the HDM approach is a proven concept and should be applied in every possible situation on new systems and applied to older systems when economic consideration justifies its use.

9.0 Recommendations

This study has evaluated application of the HDM technology to PEO AMD systems, Black Hawk, and Sentinel. The evaluation of Program Executive Office Tactical Missile (PEO-TM) weapon systems should be undertaken and an analysis of other Army commands hardware power requirement should be analyzed. Paragraph 7.2 of this study has established the current performance envelope of the HDM industry and this data should be used to evaluate additional applications of the technology throughout the Army and with other services. It is recommended that AMCOM RDEC be funded to conduct a follow-on engineering study directed toward applying the HDM technology to general-purpose power supplies. Since CECOM manages most non-system non-peculiar power supplies used by the Army, this can be done by evaluating a subset of their units and presenting the results (to include cost avoidance) to the managers at CECOM. A proof-of-principal exercise could be conducted in the AMCOM RDEC or at one of the HDM prime vendors' plants. This approach could be leveraged for future efforts with other services. This would represent an extension of this study to cover needs of additional Army and other service's systems. The HDM technology infusion should be advanced for all systems.

It is also recommended that each specific application considered have a feasibility analysis developed that evaluates the system requirements and cost avoidance/savings associated with the implementation of the HDM technology. The return on investment and break-even points should be determined in order to prioritize activity decisions. The new, emerging systems should be encouraged to apply the technology as the needs for a power supplies arises.

9.1 PATRIOT

PATRIOT is well into the incorporation of this technology for the five power supplies under contract to Rantec. Upon completion of the system level test/verification and validation of the failure rates and cost avoidance, the program management office should evaluate the remaining peculiar power supplies for this approach. This effort should be extended to cover the common stand-alone power supplies. These units are managed by CECOM and the modification would require coordination and acceptance by the various other users; however, this effort would pay big dividends since there are numerous users and therefore a significant quantity in the field.

9.2 THAAD

THAAD is a prime candidate for incorporation of the HDM technology. The hardware prototype has been built and limited testing is complete. The power supplies have been defined by the prime contractor and their requirements relayed to the power supply vendors. The timely infusion of this technology could circumvent future problems while integrating the approach before system production proceeds. The actions required to implement this approach would of necessity involve the cooperation of the prime contractors. With each power supply identified

(Table 7.3-5) the prime should be requested to evaluate each application for use of the standardized approach. It is likely that the Government would encounter resistance and incur liability were it to require application of any specific technology. However, a consideration can be requested, with the Government being in the information loop on the use decision.

The THAAD hardware has not been fielded, therefore, the decisions cannot be justified by a support cost comparison. The approach must be based on the calculated failure rates of the existing versus a new HDM MTBF.

9.3 National Missile Defense (NMD) Radar

The NMD radar is in a life cycle position similar to that of THAAD and a prototype of the hardware has been built. All available data indicates that the NMD and THAAD radar are very similar. The same prime contractor was used in both situations. This is a fixed site unit and quantities will probably be low; therefore, savings/improvements should be tempered by this knowledge. The program acquisitions are under the new guidelines and no deliverable TDP will be available. In this case, the actions needed to consider the HDM technology infusion would require a limited effort by the prime contractor. The power supply list for THAAD (Table 7.3-5) should be screened against the contractor's "as-built" files for the NMD radar with the same consideration given to both systems. The total power supply requirements in the as-built record should be compared to the THAAD list and disparities reconciled. If there are additional power supplies not used in the THAAD, each should be evaluated for standardization.

9.4 Joint Tactical Ground Station (JTAGS)

JTAGS is well along in its development and is primarily an integration of COTS hardware. With this approach and its inherent lack of documentation, influence by the Government efforts will be limited. The integration contractor should be provided with the COTS HDM capabilities and requested to consider the application in their hardware programs. Again, a feedback loop should be established in order for the Government to have knowledge of related activity and provide inputs of other new technologies that could influence the design

9.5 Medium Extended Air Defense System (MEADS)

MEADS has not entered the hardware definition phase of development. The multi-country effort makes HDM or any other technology infusion difficult. The power requirements, both from an input and output perspective, is unknown at this point. The action the Government should take is to provide the capabilities of the HDM technology to the system developer/integrator and request HDM consideration in the new design. If the contractor can see that this is a mature, cost saving, and reliable approach for the new system, it should be willing to incorporate HDM into the system design. The Government should make sure they are in a position to monitor the activity and provide inputs if requested by the prime contractor.

9.6 ARROW

ARROW is an Israeli built system and influence from the Government standpoint is very limited. The capabilities, cost avoidance, and reliability of the HDM approach should be made available to the developers through the U.S. manager of this program. The data could influence the life cycle cost as the system matures.

9.7 Black Hawk

The Black Hawk is at a point in the life cycle where infusion of new technology requires additional design activity. In Black Hawk, all power supplies documented were managed by CECOM and changes would require extensive coordination to ensure all applications are serviced.

9.8 Sentinel

The Sentinel has two AMCOM-managed power supplies which are expensive and in the past have experienced procurement problems. These units are well within the HDM performance envelope and should be considered for conversion. The power supplies are not well documented but the input, output and interface are defined. With this data and the physical characteristics, the design would be straightforward. The other power supplies in this system are managed by CECOM and any change there would require coordination with the other users.

ACRONYMS LIST

A	Ampere
AC	Alternating Current
AMCOM	US Army Aviation and Missile Command
ASL	Authorized Stockage List
BIT	Built-In-Test
CAGE	Commercial And Government Entity Code
CCSS	Commodity Command Standard System
CECOM	US Army Communications and Electronics Command
COTS	Commercial-Off -The-Shelf
DC	Direct Current
DOD	Department Of Defense
DMWR	Depot Maintenance Work Requirements
DSP	Defense Standardization Program
ECM	Electronic Countermeasures
EMI	Electromagnetic Interference
FEDLOG	Federal Logistics Data Base
GOTS	Government-Off-The-Shelf
HDM	High Density Module
HZ	Hertz
JTAGS	Joint Tactical Ground Station
LCC	Life Cycle Cost
LCN	Logistic Control Number
LRU	Line Replaceable Item
LVPS	Low Voltage Power Supply
MEADS	Medium Extended Air Defense Systems
MICOM	US Army Missile Command
MLRS	Multiple Launch Rocket System

MTBF	Mean Time Between Failures
MS	Millisecond
MTTR	Mean Time to Repair
NATO	North Atlantic Treaty Organization
NDI	Non-Developmental Item
NMD	National Missile Defense
NSN	National Stock Number
O&S	Operations And Support
OSMIS	Operations And Support Management Information System
PA	Procurement Authority Funds
PEO-AMD	Program Executive Office – Air & Missile Defense
PEO-TM	Program Executive Office Tactical Missile
PFC	Power Factor Correction
R&D	Research And Development
RAM	Reliability, Availability, Maintainability
SEPD	System Engineering And Production Directorate
SMA	Standardization Management Activity
TDP	Technical Data Package
THAAD	Theater High Altitude air Defense
TOE	Table of Organization and Equipment
UPS	Uninterruptible Power Supply
VAC	Volts Alternating Current
W	Watts
VDC	Volts Direct Current
VHF	Very High Frequency

STUDY REFERENCES

NUMBER	TITLE	DATE
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